STATE & PRIVATE FORESTRY
FOREST HEALTH PROTECTION
SOUTH SIERRA SHARED SERVICE AREA

Report No. SS18-002

May 27, 2018
File Code: 3400

To: Jason Kuiken, Stanislaus National Forest, Forest Supervisor
Scott Tangenberg, Stanislaus National Forest, Deputy Forest Supervisor
Ray Cablayan, Calaveras Ranger District, District Ranger
Joe Aragon, Calaveras Ranger District, Resources Supervisor

From: State and Private Forestry, Forest Health Protection, South Sierra Shared Service Area

Subject: Arnold-Avery Healthy Forest Restoration Project 2018

Introduction

The Arnold-Avery Healthy Forest Restoration project area is located primarily west of the communities of Arnold and Avery on the Calaveras Ranger District, Stanislaus National Forest, Calaveras County. A small Forest Service (FS) holding is also a proposed unit located east of Arnold, along Love Creek. Project boundaries are along wildland-urban interfaces (WUI) and some main roads. Elevations range between 3,000 and 4,500 feet which is primarily a mixed-conifer type in the Sierras. A large portion of proposed treatment areas is along Arnold Rim Trail – a popular recreation route. The southern portion of the project are composed of 20-25 year old ponderosa pine plantations initiated after 1992 Old Gulch fire. In 2015, O'Neil Creek, Upper San Antonio Creek, and Lower North Fork Stanislaus River watersheds were designated as priority treatment areas in Region 5 due to loss and continued potential loss from pest activity (R5 Insect & Disease treatment area designation request 2015).

The project meets **2014 Farm Bill** criteria:

- Area has been experiencing moderate to severe bark beetle associated mortality, leading to declining forest health and high potential for catastrophic wildfire
- National Insect and Disease Risk Map (NIDRM 2012) estimated that many areas within the project boundary are at serious risk of insect and disease mortality in the next 15 years
- The volume of dead trees pose a serious risk to public infrastructure and safety

Main project objectives are to implement various types of vegetation management in order to create resilient and resistant conditions against major natural disturbances such as native pests or wildfires while also providing for public safety and community protection. Restoring selected units back within range of historical variation will be conducted mechanically, by hand, or prescribed fire. Proposed strategies follow North et al. 2009 *An Ecosystem Management Strategy for Sierran Mixed Conifer Forests (GTR-220)* which emphasizes designing treatments based on natural topography and increasing heterogeneity. Hazardous tree removal along roads or other selected units will reduce risk for public as well as treatment operators.

Current Conditions and Associated Bark Beetle Mortality

Mortality patterns and trends are exemplary of historic bark beetle activity in California: drought triggers eruptions of insect infestations, subsiding when average precipitation returns above normal (Oblinger et al. 2012). However, the recent drought event found the level of tree kill in many locations in the southern Sierras to be so severe, they are categorized as deforested (Piles and Rojas 2015). Bark beetle activity began as moderate transitioning to very severe in and around Arnold-Avery project as observed from Aerial Detection Surveys (ADS) beginning in 2015, through 2016 and 2017 (Forest Health Monitoring 2015-2017)(see Appendix A). 2016 appeared to be the worst year of infestation when much of the project area was observed with some degree of mortality. Large groupings of mature ponderosa pines were killed by bark beetles – particularly sites where pines were dominant tree type. A large percentage of mortality detected in 2016 and 2017 was along ridgeline (5N52 road) and south-facing slopes – drier aspects than north-faces. Mortality polygons ranged from 300 to 1000 acres, averaging 20 trees killed per acre (ADS 2016).

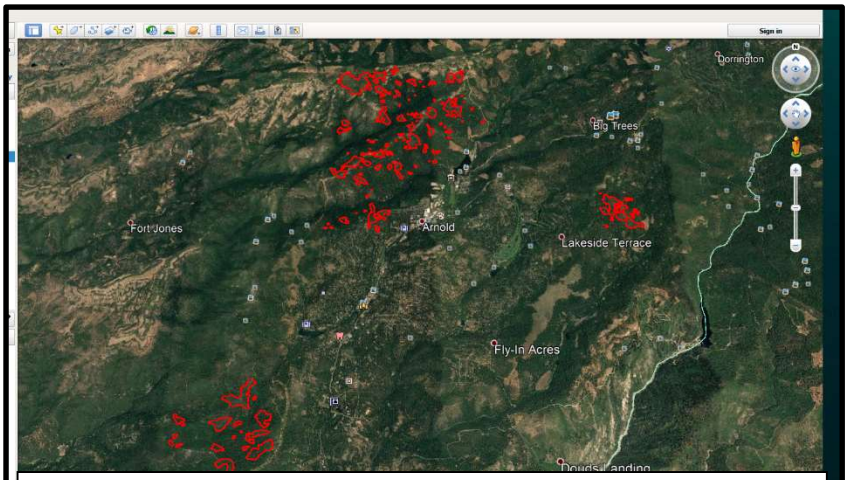


Figure 1. Google Earth™ Image of Arnold-Avery Project where pockets of the severe mortality were designated.

NIDRM[1] modeling highlights parts of the project estimated to lose >25% of the standing basal area was compared to ADS acres that were actually affected. The severity of the mortality viewing Google Earth™ images (2017 image, see Figure 1) and ground observations unfortunately validates much of expected losses in NIDRM. Some degree of bark beetle-associated mortality occurred over all of the project area in the last three years of the recent drought, some areas detected with consecutive years of activity (see Appendix A). Large polygons of dead overstory pines are visible in the aerial image, nearly 100% kill when ground checked (see Figure 2). Common stand characteristics among infested stands: basal areas >200 square feet per acre, > 60% ponderosa pine composition, and average diameters of ponderosa pines greater than 15 inches. San Domingo plantations west of Avery (~24 years old) have infestations in groups of 10-20 trees, staggered mortality indicating multiple years of activity. Secondary insects were observed in plantations, but dead ponderosa and sugar pines along the ridgeline were killed by primary bark beetles.

Figure 2. Grouping of dead ponderosa pine killed by western pine beetle. Some hazard abatement has already occurred here.

Primary bark beetles such as western pine beetle (*Dendrocotnus brevicomis* Hopkins) and mountain pine beetle (*Dendroctonus ponderosae* Hopkins) benefit when conditions are favorable for population growth and distribution. Severe drought events or shifts in longer term climate patterns provide optimal temperatures for larval growth and plentiful (weakened) hosts for selection. Beetle survival relies on the availability of suitable hosts for reproduction and brood development. Multiple studies consistently find that improving vigor of host trees, alterations in

[1] *National Insect and Disease Forest Risk Assessment 2013-2017 (National Insect and Disease Risk Map (NIDRM) is a nationwide strategic assessment and database of the potential hazard for tree mortality due to major forest and diseases. Risk in these models was the expectation that, without remediation, at least 25% of the standing live basal area great than one inch in diameter will die over a 15-year time frame due to insects and diseases.*

microclimate, or increasing structural and compositional diversity are most effective management strategies for long-term prevention (Fettig et al. 2007, Fettig and Hilszczanski 2015).

White fir polygons were not so discernable until 2017 around Calaveras Big Trees State park and Love Creek area (FHM ADS 2017). White fir mortality is scattered across the landscape rather than grouped as ponderosa pines. The level of mortality in these areas ranges from 5-20 trees killed per acre (severe mortality (>50% affected)). Density of dominant white fir stands are typically much higher than those of pines, thereby actual number of trees dead per polygon is also higher than aerially observed as much of the understory is often dead as well and not seen from the air. Drought effects have caught up in shady, high moisture stands where all size classes are typically affected and infested by a complex of damage agents. As water deficit is prolonged during severe droughts, the moisture buffer of elevation eventually collapses and trees become susceptible to death from multiple factors (Young et al. 2017). Suppression causes a significant amount of stress rendering trees also susceptible to other damage agents (Das et al. 2016), this is often noted in white fir regeneration under dense canopy cover (FHP, *personal observations*). In addition, mortality may still continue at elevated levels directly due to loss of tree vitality rather than bark beetles (Berdanier and Clark 2015) as resource competition tightens in denser stands (Young et al. 2017).

Discussion: Bark Beetles

In GTR 237 Fettig (2012, Chapter 2: Bark beetles) surmised that bark beetle abundance is a good measure of ecosystem condition or how ecosystems respond to natural disturbance. High levels of infestations indicate that conditions were optimal for beetle growth and expansion (positive feedback loops) (Raffa et al. 2008, Bentz et al. 2010), which consequently results in higher levels of tree mortality. If current conditions are preferable for future widespread bark beetle epidemics, then project strategies should focus on mitigating or forestalling them. Even with above normal rainfall of 2016-2017, trees have suffered long-term stress due to severity of the recent drought, that elevated mortality can still occur as tree slowly recover. According to Young et al. (2017), sites with lower basal area could better withstand effects of severe drought than those of intermediate to high basal areas. Intermediate density stands also broke down quickly as the drought progressed, despite having moderate CWD[2] (Young et al. 2017). Bark beetles have already killed large groups of trees along the Rim trail and south-facing slopes, but high risk areas still remain.

Treatments proposed for Arnold-Avery concur with recommendations for general bark beetle prevention. Reduction of stand density is good, but better when they meet thresholds below levels of eminent mortality, best when those levels can be maintained for at least 20 years forward. Complete protection is not possible, but reduction in average loss is desirable and keeps activity at background levels. GTR 220 guidelines are suggested when designing thinning prescriptions to fit drier south- and wetter north-faces along the Rim Trail to reduce further beetle activity (GTR 237, Fettig 2012). Trees on drier sites may already be existing in narrow climatic tolerances, while wetter sites have wider ranges (Young et al. 2017). Within ponderosa pine forest types, an SDI of 220 is recommended (Oliver 1995, Oliver and Uzoh 1997, Zhang et al. 2013) with drier sites possibly averaging less if warmer temperatures are expected in the future. The distribution of beetle mortality in the project area is very indicative of where beetles attack initially when searching for weak hosts. Colder wet sites may have a higher carrying capacity but easily succumb when drought occurs if trees are chronically struggling from resource competition (Gleason et al. 2017). These sites are often higher in white fir composition than pines but all trees are more susceptible to damage agents if overstocked. Egan et al. (2009) determined that for white fir dominated stands, percent mortality of white fir was higher in non-thinned stands than previously treated stands. However during drought events, lower density white fir stands may still experience high loss of fir regardless due to currently higher proportions of fir than historically (Egan et al 2009). Prevention treatments during average to good precipitation years in California is preferable when competition for resources and water stress is lower, and tree defenses are fairly adequate to repel attacking beetles.

---

[2] *CWD: 35-year (1981-2015 time period) mean annual climatic water deficit analyzed at regional scale (California) (Young et al. 2017).*

Figures 3 & 4. View of tree mortality within San Domingo plantation. Trees in the bottom were killed by woodborers, while those on the upper slopes were resisted mass attack by pine engravers.

No western pine beetle was found in San Domingo plantations since average stem diameter (~8-10 inches) is marginal for this beetle, but sufficient for pine engraver or woodborers. Outbreaks do not usually happen with these latter beetles, but given the proper conditions, they can infest a sizeable number of trees. Many of the infested trees were at the bottom of the valley, or surrounding the meadow (see Figures 3&4). It is likely that drought conditions here stressed pines that were adjusted to high water tables. Woodborers are usually indicative of dying/dead trees compared to bark beetles, trees were completely infested but wood was still surprisingly moist when examined. Pine engravers were working on the tops of a few trees along meadow edges, but these trees appeared able to withstand mass attack. Thinning treatment is recommended in this plantation by increasing spacing of remaining trees to improve tree vigor which quickly deters most damage agents.

Pine engravers do have several generation per year, and will move from green slash to neighboring hosts if populations are allowed to build in slash piles. Several piles of green slash from recent treatments were found to have harbored pine engravers which moved to natural regeneration nearby. Moving piles away from susceptible sized hosts, or additional treatment on slash making it initially unsuitable for infestation are adequate prevention measures (DeGomez et al. 2008).

SPLaT™ is a commercially registered pesticide most effective on lodgepole and sugar pines to prevent mountain pine beetle (*Dendroctonus ponderosae*) attack. The active ingredient for this product is verbenone which as has been shown to have some deterrent properties against *Dendroctonus spp*. The formulation is a synthetic anti-aggregation compound found to discourage beetles from initiating attack on treated trees. Treatments are effective for one season only, and biodegradable; continued protection would require reapplication as needed. Treatments are fairly cost-effective in comparison to high-pressure sprays, hand application is required. Utilization of SPLAT is encouraged, especially if beetle activity in neighboring areas have been relatively high or drought conditions return by time of project implementation.

Bark beetle-associated mortality and correlation with catastrophic wildfire studies are still on-going, but research of potential fire behavior has been summarized by Hicke et al. (2012). In compilations of studies conducted in Rocky Mountains of lodgepole pine killed by mountain pine beetle, they surmise that while fire behavior is variable between red phase to grey phase, long-term fuel loading (ex: 100 and 1000-hour fuels) will significantly increase as dead trees begin to fall over. Therefore, removal of some dead trees can aid in ecosystem resilience by decreasing potential for severe wildfires, and improving wildland interface defense zones.

Root rots.

Heterobasidion root disease is likely to impact this project; even then only one species is likely to be a major problem (Cannon et al. 2016). *Heterobasidion occidentale* (aka the fir or "S" type) is a very common root disease of true firs. To prevent further introduction of the disease into uninfected cut stumps regardless of species, there is an effective, cost efficient means of disease mitigation (Graham 1971, Smith 1970). Kleijunas (1989) summarized the existing literature on borax effectiveness in the pine type. Although the other species *H. irregulare* (aka the "P" or pine type) is uncommon on Stanislaus National Forest, once established it can only be eradicated by species conversion away from pine. Because it is such a cheap insurance against all *Heterobasidion* species, it is recommended that all stump species greater than 10 inches be borate treated.

Mitigation methods are described in the R05 *Heterobasidion* root disease web page at:
http://www.fs.usda.gov/detail/r5/forest-grasslandhealth/insects-diseases/?cid=stelprdb5329386
The actual Regional Policy is described in the FSH FSH 3409.11 at:
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5329399.pdf
Additionally this first web link provides additional links to commonly asked questions about the treatment. These answers have been used to successfully answer most questions based on other projects. FHP is available not only to find answers to other questions, but to provide training in the application of these preventative measures if needed.

White Pine Blister rust

Of the introduced diseases, White Pine Blister Rust (WPBR), caused by *Cronartiun ribicola*, is the most serious threat to the continued health of the white pines within this project. While the fungus will attack most 5-needled pines it poses the most serious risk for the continued health of the sugar and western white pines in this project. USFS has established a breeding program to provide the forests with seed from selected sugar pine mother trees that have proven to possess major genes for rust resistance. The known resistant mother trees have been identified and fitted with squirrel-proofing bands. These bands prevent squirrels from climbing the trees and eating the seed. To enable the restoration of this species, it is essential to have continued supply of resistant seed thus the proven rust resistant gene bearing mother trees must be retained and squirrel-proof. As the forest ages the crowns of adjacent trees can intermingle with the sugar pine crowns, thus squirrels can climb adjacent trees to gain access to the sugar pine cones. To reduce squirrel caused seed predation and reduce the risk of ladder fuels leading to a crown fire, all trees within the drip line of the proven resistant mother trees should be thinned out. While it would be optimally desirable to have each resistant tree radially thinned to 1½ the tree crown radius, it will be adequate to ensure that there is a 25 foot gap (looking upwards) between the crown of the resistant mother tree and the crowns of all adjacent trees. This gap will provide a distance that squirrels will not be able to jump and will provide growing space for the tree crowns to expand into over the next 15 - 20 years. Because there is nothing intently special about the candidate trees, trees bearing a "candidate" tag need no special attention. These trees do not possess any genes for resistance.

If there are further questions regarding Arnold-Avery Farm Bill discussion, or concerns regarding this report, please do not hesitate to contact us.

Beverly Bulaon
Entomologist
Forest Health Protection
(209) 288-6347
bbulaon@fs.fed.us

Martin MacKenzie
Plant Pathologist
Forest Health Protection
(209) 288-6348
mmackenzie@fs.fed.us

References.

Bentz, B., J. Regniere, C.J. Fettig, M. Hansen, J.L. Hayes, J.Hicke, R.G. Kelsey, J.F. Negron, and S.J. Seybold 2010. Climate Change and Bark Beetles of the Western United States and Canada: Direct and Indirect Effects. Bioscience 60(8): 602-613.

Berdanier, A.B. and J.S. Clark 2015. Multi-year drought-induced morbidity preceding tree death in Southeastern US forests. Ecolological Applications, 6:17–23

California Forest Pest Conditions 2015, 2016, 2017. Publication of California Forest Pest Council, Sacramento, CA.

Cannon P.G., Angwin p., MacKenzie M. 2016. Chapter 20: Diseases of Conifers in California *In* Paine T.D. & F. Lieutier *eds*,: Insects and Diseases of Mediterranean Forest Systems. Soringer 892 pp.

Das, A., N. Stephenson, K. P. Davis. 2016. Why do Trees Die? Characterizing the drivers of background tree mortality. Ecology, 97(10).

Egan, J., W.R. Jacobi, J.F. Negron, S.L. Smith, and D.R. Cluck 2010. Forest Thinning and subsequent bark beetle-caused mortality in Northeastern California. Forest Ecology and Management 260 (10): 1832-1842.

DeGomez, T., C. Fettig, J.D. McMillan, J.A. Anhold, and C. Hayes 2008. Managing Slash to minimize colonization of residual trees by *Ips* and other bark beetle species following thinning in southwestern Ponderosa pine. University of Arizona, Cooperative Extension, Publication AZ1448.

Fettig, C., K. Klepzig, R.F. Billings, A.S. Munson, T.E. Nebeker, J.F. Negron, and J. T. Nowak 2007. The effectiveness of vegetation management practices for prevention and control of bark beetle infestations in coniferous forest of the western and southern United States, Forest Ecology and Management, 238: 24-53.

Fettig, C.J. 2012. Chapter 2: Forest Health and Bark beetles. *In*: North, M.P., ed. Managing Sierra Nevada forests. General Technical Report, PSW-GTR-237. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

Fettig, C.J. and J. Hilszczanski 2015. Chapter 14: Management Strategies for Bark Beetles in Conifer Forests. *In* Bark Beetles: Biology and Ecology of Native and Invasive Species. London, Springer publishing. 555-584.

Forest Health Monitoring Aerial Detection Surveys 2015, 2016, 2017. USDA Forest Service, Pacific Southwest Region, Forest Health Monitoring. https://www.fs.usda.gov/detail/r5/forest-grasslandhealth/?cid=fsbdev3_046696

Fowells, H.A. 1965. Silvics of Forest Trees of the United States. USDA Forest Service, Agricultural Handbook No. 271. 762 pg.

Gleason, K.E., J. Bradford, A. Bottero, A.W. D'Amato, S. Fraver, B.J. Palik, M. Battaglia, L. Iverson, L. Kenefic, and C.C. Kern 2017. Competition Amplifies drought stress in forests across broad climatic and compositional gradients. Ecosphere, 8 (27)e01849.

Graham, D.A. 1971. Evaluation of borax for prevention of annosus root rot in California. Plant Disease Reporter 55:490-493 *https://pdfs.semanticscholar.org/4ac0/5a09310851dfe7ad7182dfb04e672bc56f19.pdf#page=156*

Hicke, J., M.C. Johnson, J.L. Hayes and H.K. Preisler 2012. Effects of Bark Beetle-Caused Tree Mortality on Wildfire. *In* The Bark Beetles, Fuels, and Fire Bibliography. Paper 223.

Kliejunas, J.T. 1989. Borax stump treatment for control of annosus root disease in the eastside pine type forests of Northeastern California. Pg. 159-166 in: Proceedings of the Symposium on Research and Management of Annosus Root Disease in Western North America. GTR-PSW-116. USDA Forest Service, Pacific Southwest Forest and Range Experiment Station.

Knapp, E.E.; M.P. North, M. Benech, B.L. Estes 2012. The variable-density thinning study at Stanislaus-Tuolumne Experimental Forest. *In*: North, M.P., ed. Managing Sierra Nevada forests. Gen. Tech. Rep. PSW-GTR-237. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 127–139.

National Insect and Disease Forest Risk Assessment 2013-2017. USDA Forest Service, Forest Health Technology Enterprise Team, FHTET-14-101, January 2014.

North, M.P. *ed*. **2009.** An Ecosystem Management Strategy for Sierran Mixed Conifer Forests. USDA Forest Service, Pacific Southwest Research Station, General Technical Rep. PSW-GTR-220. Albany, CA.

North, M.P. *ed*. 2012. Managing Sierra Nevada forests. Gen. Tech. Rep. PSW-GTR-237. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 127–139.

Oblinger, B., L. Fischer, Z. Heath, and J. Moore 2012. Can any recent trends involving drought severity and bark beetles be attributed to tree mortality in California? Forestry Source: 12 & 15.

Oliver, W. W. 1995. Is Self-thinning in Ponderosa Pine ruled by *Dendroctonus* Bark Beetles? *In* Proceedings of 1995 National Silvicultural Workshop. USDA Forest Service, Rocky Mountain Research Station, GTR-RM-267, Fort Collins, CO., pp 213-218.

Oliver, W.W. and F.C.C. Uzoh 1997. Maximum stand densities for ponderosa pine and red and white fir in Northern California. In: Forest Vegetation Management Conference. Proceedings of the Annual Forest Vegetation Management Conference Symposium Proceedings, pp. 57–65.

Piles, L. and R. Rojas 2015. November 2015 Presentation at Sierra National Forest, Clovis, CA.

Raffa, K.,B. Aukema, B.J. Bentz, A.L. Carroll, J.A. Hicke, M.G. Turner, and W.H. Romme 2008. Cross-scale Drivers of Natural Disturbances Prone to Anthropogenic Amplification: The Dynamics of Bark Beetle Eruptions. Bioscience, 58 (6): 501-517

Smith, R.S. Jr. 1970. Borax to control *Fomes annosus* infection of white fir stumps. Plant Disease Reporter, 54:872-875.

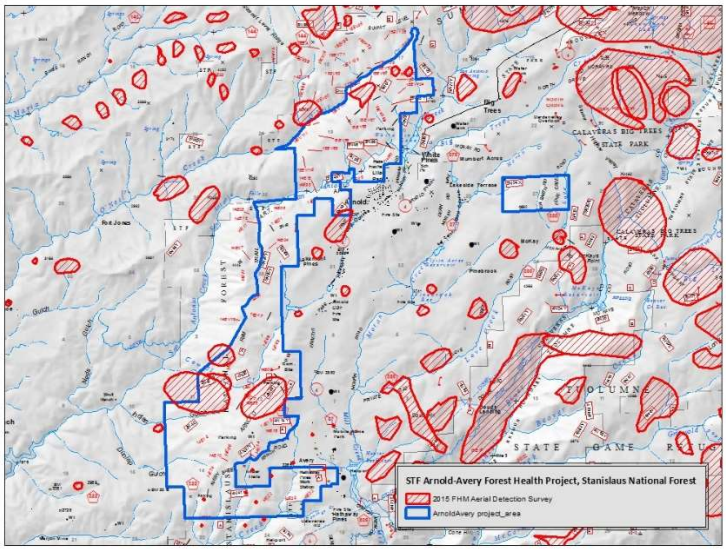
Thistle, H.W., B. Strom, T. Strand, H.G. Peterson, B.K. Lamb, S. Edburg, and G. Allwine 2011. Atmospheric Dispersion from a Point Source in Four Southern Pine Beetle Thinning Scenarios: Basic Relationships and Case Studies. American Society of Agricultural and Biological Engineers, 54(4): 1219-1236.

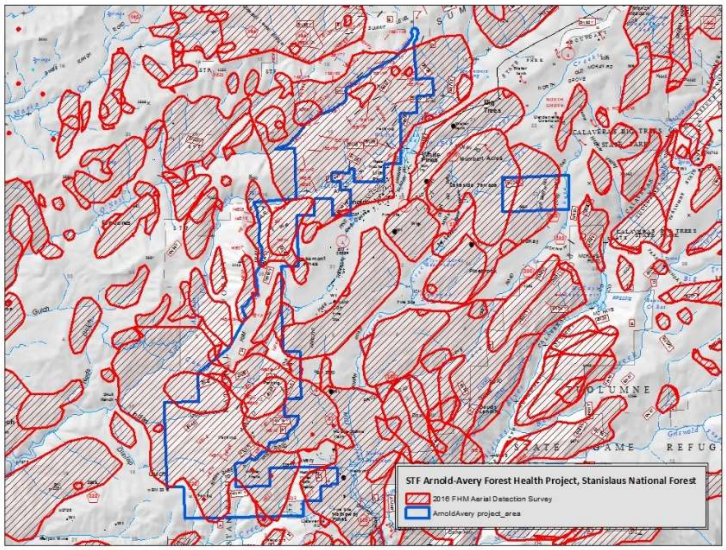
Wood, D.L., T.W. Koerber, R. Scharpf, and A.J. Storer 2003. Pests of the Native California Conifers. University of California Press, Berkeley, CA.

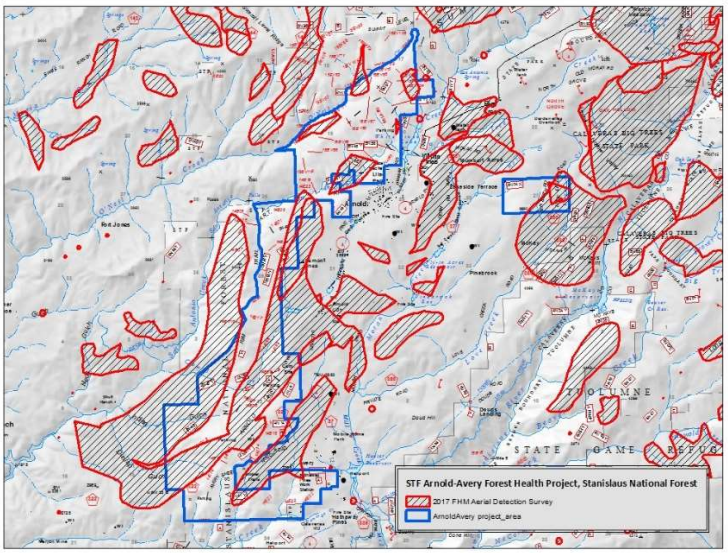
Young, D., J.T. Stevens, J.M. Earles, J. Moore, A. Ellis, A.L. Jirka, and A.M. Latimer 2017. Long term climate and competition explain forest mortality patterns under extreme drought. Ecology Letters, 20: 78-86.

Zhang, J., M.W. Ritchie, D.A. Maguire, and W.W. Oliver 2013. Thinning ponderosa pine (*Pinus ponderosa*) stands reduces mortality while maintaining stand productivity. USDA Forest Service, Pacific Southwest Research Station, Canadian Journal Forest Research, 43: 311–320

Appendix A. FHM Aerial Detection Mortality Surveys 2015, 2016, 2017 within and around the Arnold-Avery Project, Calaveras Ranger District, Stanislaus National Forest. *Note: expansion of mortality from 2015 to 2016, but shift of mortality from pine to fir by 2017.*


STF Arnold-Avery Forest Health Project, Stanislaus National Forest
2015 FHM Aerial Detection Survey
ArnoldAvery project_area


STF Arnold-Avery Forest Health Project, Stanislaus National Forest
2016 FHM Aerial Detection Survey
ArnoldAvery project_area


STF Arnold-Avery Forest Health Project, Stanislaus National Forest
2017 FHM Aerial Detection Survey
ArnoldAvery project_area